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ABSTRACT

This discussion of the quality and impact of the prior knowledge state presents theoretical and empirical explorations. The theoretical discussion offers a distinct approach to the analysis of prior knowledge based on an extensive literature review of theory, models, and practice about the structure of knowledge. This base is used to define a set of dimensions that are useful in constructing knowledge profiles. The dimensions are: (1) cognitive-psychological; (2) educational-psychological; (3) psychometric; and (4) content-based. In a discussion of empirical results, the dimensions are used to analyze the knowledge profiles of 591 economics students at the Open University of the Netherlands and the Maastricht University with low and high levels of prior knowledge of economics. In this sample, profile analysis did not help to reveal specific significant differences between the two subpopulations, although the research was helpful in defining and operationalizing a new approach to the analysis of prior knowledge states. Ten tables and 23 figures illustrate the investigation. (Contains 31 references.) (SLD)

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Knowledge Profiles of Students with Low and High Prior Knowledge States

M.M.A. Valcke

F.J.R.C. Dochy

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- the developments of the "Computer Assisted Testing"-project;
- the developments of "Adaptive Testing" and the IRT-applications (Item-Responds Theory); and
- the experience of the Open University with the development and use of TSS (Test service systems).

The main objectives are: (1) to get a discernment of the test and evaluation problems in the open-learning system; (2) the generation of the guide-lines, specifications, and technological instruments concerned with the use of prior knowledge and experience, flexible testing and the supervision on students during the learning process, and (3) the development of instruments which can be useful in solving the given teaching problems.

Centre for Educational Technology and Innovation
Open University

Knowledge Profiles of Students with Low and High Prior Knowledge States

OTIC Research Report 35

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1 Introduction

The analysis of the quality and impact of the prior knowledge state has been the major focus in a large part of our earlier research. In analyzing the prior knowledge state, we did especially focus on the structure of the prior knowledge state along a content dimension.

In the theoretical part of this text, we discuss - in short - a distinct approach towards the analysis of the prior knowledge state[1]. This approach is based on an extensive analysis of the literature in relation to theories, models and practice-based strategies about the "structure of knowledge". This base is exploited to define a set of "dimensions" that are helpful to construct "knowledge profiles". Four types of dimensions are illustrated : cognitive psychological dimensions, educational-psychological dimensions, psychometrical dimensions and content-based dimensions.

In the empirical part of this text, the dimensions are used to analyze the knowledge profiles of students with low and high levels of the prior knowledge state. The results of this analysis might not only be helpful to detect specific differences in the mastery of components of the prior knowledge state between both student populations, but might also be helpful to provide further evidence about the validity of the theoretical knowledge profile dimensions.

2 Theoretical background

2.1 The Structure of Knowledge

From an instructional-psychological point of view, the structure-of-knowledge problem should be investigated in order to find out more efficient ways for using instructional technology. Our search for means to handle the prior knowledge state showed that one should take account different **components of the prior knowledge state**. The concept of "components" refers towards a structure in the knowledge base of the learner.
Our earlier research was helpful to detect such components of the prior knowledge state along the content dimension. But it was also suggested that the differentiation of components of the prior knowledge state along other dimensions is needed to be helpful to interfere and diagnose educational practice (Dochy and Valcke, 1991; Dochy and Valcke, 1991b; Wagemans, Valcke and Dochy, 1991).

The issue of the "structure of knowledge" has been debated from a variety of theoretical points of view : cognitive psychology, epistemology, philosophy, etc. At the more pragmatic level, the issue has also been of prime importance in applied sciences like instructional psychology, curriculum development theories and psychometry.
Disciplines like cognitive psychology, educational psychology, artificial intelligence, etc. - have - from their points of view - highlighted the "structure of knowledge" resulting in a puzzling variety of approaches, focuses, models, theories, research attempts, ... A representative sample of authors comprises e.g. Ausubel (1968), de Groot (1946), Mayer (1979), Reigeluth and Stein (1983).

It should be noted that our primary focus in using these theories originates from an information processing view on learning (Sternberg, 1985a & 1985b). The main reason for this is that we stress a dynamic approach towards the structure (knowledge acquisition) of knowledge, which is in particular advocated in this view. If we summarize the variety of approaches, four main types of dimensions to structure knowledge can be conceptualized :

[1] A more elaborated version of the theoretical base of the knowledge profile dimensions can be found in : Dochy & Valcke (1991a). Validation of Knowledge Profile Dimensions : Looking for empirical Evidence. OTIC Research report 33. Heerlen : Ou-OTIC.

Content related dimensions
Educational dimensions
Epistemological dimensions
Item characteristic dimensions

As discussed in another publication (Dochy and Valcke, 1991), some of these dimension are of a hierarchical nature.

2.2 Knowledge Profiles

As such, the concept of 'knowledge profiles' is not found in literature. Only 'student profiles' (Wolf, et. al., 1991) and 'cognitive profile' (Letteri, 1980) have some similarity in meaning. This is certainly the case for the studies by Letteri et. al. (1980, 1982). The concept 'profile' is derived from the practice, common in educational research, of plotting as a graph or profile the scores of a person as raw scores or as standardized scores (Keeves, 1988). In analyzing research findings, comparisons are made between persons or groups in terms of a set of measurements on specific related aspects. For each person or group a profile is obtained on a set of parameters. The comparison between profiles of persons is known by the generic term 'profile analysis'.
Figure 1 shows the relationship between some key concepts. A "dimension" is used to construct a knowledge profile. Each dimension represents an approach towards the structure of knowledge. The structure components are named "parameters".

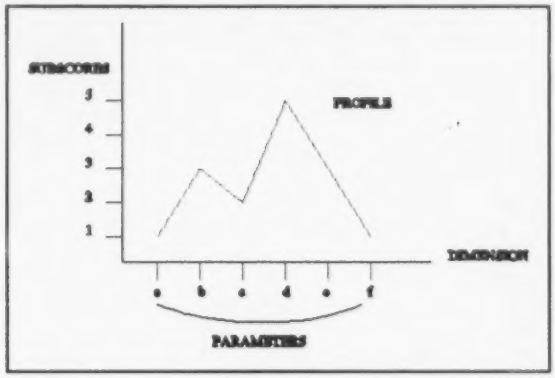

Figure 1: Example of a profile

From an instructional psychological point of view, knowledge profiles can give practical indications of student achievement and learning in order to direct the learning process. In a recent overview of student assessment, Wolf et. al. (1991) advocate this approach. According to these authors, there is a need for new educational psychometrics capable of answering the much changed question of educational achievement. These changes are the new premises, the multiple paths towards the prior knowledge state, more developmental oriented assessments and the ascertainment that students enter school with widely varying backgrounds. In our terms, we take account of these changes by trying to identify multiple components of the prior knowledge state, by implementing prior knowledge state tests and by intending to use these tests as progress tests administered several times a year. In this context it is necessary to come to an agreement on the relevant parameters to describe student performance and it is critical to develop ways of looking at 'student profiles': " unless we develop these kinds of differentiated portraits of student performance within a domain, it is difficult to envision student assessment ever informing, rather than merely measuring, the educational process" (Wolf, et. al., 1991).

2.3 Overview of Knowledge Profile Dimensions

Only those dimensions/parameters are reviewed that have been retained after their discussion and analysis in our earlier publication "Validation of Knowledge Profile Dimensions : Looking for empirical Evidence".
If dimensions are based on a model or theory, only short details will be reported.
The first dimensions are classified according to common models of economics. Other dimensions are based on theories of knowledge representation, knowledge structure, learning theories, text representation models and psychometric theory.

2.3.1 Content Dimensions

Economics subdomains dimension

"Content" is a commonly used dimension to categorize domain knowledge. Classification based on the parameter 'subdomains' refers to the subdivision of the economics-domain into "subject matter blocks" that are standard within the science of economics. Our dimension structure is e.g. based on the curriculum structure of the University of Maastricht and reflects 9 parameters :

1. Reporting
2. Financing
3. Organization
4. Marketing
5. Macro-economics
6. Micro-economics
7. Public finances
8. International economic affairs
9. Behaviourial and social sciences

Curriculum level dimension

Some parts of the content of a science are supposed to be mastered by the students at certain moments during their study. These moments are called the curriculum levels (first and second year). These levels are subsequent, but too broad to be supposed hierarchical.

1. First year level
2. Second year level

Curriculum accent dimension

Within economics it is common to differentiate between two main streams, representing a different accent, i.e. general economics and business administration on the one hand and quantitative economics on the other hand.

1. General economics and business administration
2. Quantitative economics

2.3.2 Cognitive Psychological Dimensions

Node relation dimension

Knowledge representation, as used in schema theories (Dochy and Bouwens, 1990), takes certain propositions or nodes as a starting point. A proposition is the smallest unit that can be qualified as true or false in a statement. According to most schema theories there are five kinds of nodes : Physical State (PS, statement that refers to an ongoing state in the physical or social world), Physical Event (PE, statement that refers to a state change in the physical or social world), Internal State (IS, statement that refers to an ongoing state of knowledge, attitude, or belief in a character), Internal Event (IE, refers to a state change in knowledge, attitude or belief in a character), Goal (G, statement that refers to an achieved or unachieved state that a person wants) and Style (S, statement that refers to details about the style or manner in which an action or event occurred.

1. G - G REASON
2. PS - G INITIATE IS - G PE - G IE - G
3. PS - PE CONSEQUENCE IS - PE PE - PE IE - PE G - PE PS - PS IS - PS PE - PS IE - PS G - PS
4. PE - S/G MANNER IE - S/G GE - S/G
5. PS - PS PROPERTY

The "Node Relation" dimension is based on characteristics of the interrelations between propositions, called node relation or arc parameters: Reason (R, a Goal node is a reason for another Goal node), Initiate (I, a State or Event initiates another Goal node), Consequence (C, a State, Event or Goal node that has the consequence of another State or Event node), Manner (M, an Event or Goal node occurs with some style), Property (P, a person, object or entity has some property that is a State node) (see also Dochy and Bouwens, 1990). These arc parameters are not of a hierarchical nature.

2.3.3 Educational-Psychological Dimensions

The theoretical base of these two dimensions - i.e. behaviourial and content dimension - is found in Component Display Theory (CDT, Merrill, 1983), Taxonomy theories (De Block, 1986 and Bloom, 1956) and Gagné's theoretical classification (1985).

Behaviourial dimension

The known distinction between declarative and procedural knowledge is further operationalised at this stage into the parameters 'to know, to understand, and to apply'. These parameters are also perceived as equivalent to the concepts 'recognition, reproduction and production'. Items can be classified as measuring the appreciation, the recognition and the reproduction of information (declarative) or measuring production or applications (interpretative, convergent, divergent or evaluative production= procedural) (Keeves, 1988).

The three parameters do also correspond with taxonomic levels proposed by several educationalists as Bloom, Guilford, De Corte and De Block (cf. Keeves, 1988). Most researchers agree that these parameters are hierarchical in nature.

1. Know 2. Understand 3. Apply	1. Declarative 2. Procedural

Content dimension

Along the content dimension we differentiate five parameters : facts, concepts, relations, structures and methods. This is in accordance with e.g. the work of Guilford when he refers to product parameters (Keeves, 1988). These parameters are widely accepted as being hierarchical (Keeves, 1988).

1. Facts
2. Concepts
3. Relations
4. Structures
5. Methods

Epistemological dimension

Based on the levels of knowledge representation of Brachman and Schmolze (1985), five parameters can be differentiated along a typical dimension. These parameters can also be considered as the most appropriate combinations of behaviourial- and content levels, as clarified between brackets : knowledge identification (identifying facts and concepts), knowledge conceptualisation (insight in concepts), epistemological analysis (to know and understand, relations and structures), logical analysis (to know and understand methods), implementational analysis (application of methods). These levels are considered as hierarchical since they are a combination of the hierarchical behaviourial and content level.

1. Knowledge identification
2. Knowledge conceptualisation
3. Epistemological analysis
4. Logical analysis
5. Implementational analysis

2.3.4 Item Characteristics Dimensions

Number of propositions dimension

A proposition is the smallest unit that can stand as a separate assertion which can be judged as true or false. In schema theories (Dochy and Bouwens, 1990), propositions or nodes have a core function in the structure of schemata. It is assumed that the amount of propositions determines the degree of structure needed to answer the item correctly. Three parameters have been identified in relation to this dimension :

1. < 5 propositions
2. > 4 < 10 propositions
3. > 9 propositions

Information level dimension

The "stem" of an item is the general information which is given and which must not be evaluated. This correct information precedes the questions for which this information should be taken into account. A stem can be connected to one or more subsequent questions. Therefore, the spatial and logical distance between the general information part of an item and the question part is larger than for simple items without a stem.

1. Items with a stem
2. Items without a stem

Representation level dimension

Following the classification used in the research of Boekaerts (1979), i.e. visual, verbal and symbolic representation, we distinguish four parameters along this dimension. These parameters are also closely related to the four content levels of Guilford's structure of intellect model: figural, symbolic, semantic (the verbal factor) and behaviourial (nonverbal information) and the Twyman (1985) categories : verbal, pictorial and schematic.

Test-items are always based on textual information representation, but can be enhanced, enriched or documented with information of an other representation category :

1. Textual-graphical
2. Textual
3. Schematic
4. Textual-symbolic

2.4 LE and HE : What are the differences in their prior knowledge state ?

Knowledge state profiles can be helpful to differentiae between students with low levels of expertise (LE) and students with high levels of expertise (HE). This might be especially interesting since this analysis can help us to detect what specific aspect of the structure of knowledge is especially differing between students with low (LE) or high (HE) expertise. The latter can be derived from the results of profile analysis when the outcome clearly shows which dimensions and/or which parameters along the dimensions can describe/explain the differences in expertise.

Of course, the reader can comment on our approach by stating that it is obvious there will be overall significant differences between the mean scores of student with low and high expertise. We agree with this comment but draw the reader's attention to the possibility that - since we work with multiple parameters along multiple dimensions - we can expect certain particularities in the pattern of differences (the profiles) for each specific dimension. So, we are not, in the first instance, interested in the significance' of differences between the results of both populations, but we are rather interested in the 'pattern' in the significant differences : Where are these differences more important, more explicit ?

3 Research design

3.1 Hypotheses

Taking into account the theoretical base of the present study, the following main hypothesis can be stated :

"Students with low and high levels of the prior knowledge state are different in terms of the variables along a variety of knowledge profiles."

Since up to 10 profile dimensions will be used, the main hypothesis can be split up into a set of 10 subhypotheses :

- Students with low and high levels of the prior knowledge state are different in terms of the **subtopics** knowledge profile.
- Students with low and high levels of the prior knowledge state are different in terms of the **course level** knowledge profile.
- Students with low and high levels of the prior knowledge state are different in terms of the **curriculum accent** knowledge profile.
- Students with low and high levels of the prior knowledge state are different in terms of the **node relation** knowledge profile.
- Students with low and high levels of the prior knowledge state are different in terms of the **behaviourial level** knowledge profile.
- Students with low and high levels of the prior knowledge state are different in terms of the **content level** knowledge profile.
- Students with low and high levels of the prior knowledge state are different in terms of the **epistemological level** knowledge profile.
- Students with low and high levels of the prior knowledge state are different in terms of the **representation level** knowledge profile.
- Students with low and high levels of the prior knowledge state are different in terms of the **number of propositions** knowledge profile.
- Students with low and high levels of the prior knowledge state are different in terms of the **stem** knowledge profile.

3.2 Research Instruments

As will be explained below, a domain specific knowledge state test was administered to the research population. This test consists of 154 items. The test covers the whole domain of economics to be studied at university level. This test consists of multiple-choice questions which can be answered with true/false or ?. The ?-alternative is taken as a third alternative in order to prevent guessing.

Characteristics of the test suggest that the determination of certain psychometric qualities might be a problem. There is no problem in relation to validity since the test clearly represents - to a very large extent - the "economics" domain and has been developed by a team of domain experts.
On the other hand, determining the reliability of the test induces some specific problems. If we calculate the alpha-coefficient, the test can be considered as very reliable : α = .9302.

Table 1 :
α-coefficients for the course subtopics and curriculum accent dimensions and mean α-coefficients

PARAMETERS	α	N_{item}	m_α
Reporting	.5739	18	
Financing	.6449	18	
Organization	.6922	18	
Marketing	.6292	18	
Macro-economics	.7069	25	.631
Micro-economics	.7420	25	
Public finances	.5101	11	
Intern. economic affairs	.5543	11	
Behaviourial & social sciences	.6287	10	
General economics & B.A.	.9270	139	
Quantitative economics	.4467	15	.686

But this high reliability level is marred by the fact that the test is very long (154 items); thus resulting rather easily in a high α-coefficient. More important, calculation of the α-coefficient supposes the test to be homogeneous. Mostly tests are homogeneous at the content level. The delineation of the knowledge profile dimensions above, indicates that this basic assumption to calculate the α-coefficient has been violated.
A solution to this problem might be to check the reliability of subparts of the test, making use of the knowledge profile dimensions.
Calculation of α was repeated for two of these dimensions (subdomains dimension and curriculum accent dimension), in order to be able to calculate a mean reliability score (m_α).
When reorganising the test into more homogeneous subparts, α-coefficient and the mean α-coefficient was calculated. The results of this procedure are summarized in table 1. To be able to judge the figures in a better perspective, the number of items each subgroup of items consists of is also given.
Mean α seems to be > .63. This reliability score is - taking into account the restricted number of items in certain subparts of the test - acceptable for our research purposes.

3.3 Research Population and Procedure

3.3.1 Research Population

The test was administered to a sample of economics students studying at the Dutch Open university and the Maastricht University. This sample consisted of 591 students.
The mean score for the test was used in order to derive the students with the 50% Highest scores (HE) and the students with the 50% Lowest scores (LE) (N=290 and N= 301). A further distinction has been made in order to derive the 25% students with the highest scores within the High score group (N=144) and the 25% students with the lowest scores within the Low score group (N=144).

3.3.2 Research Procedure

The domain specific knowledge state test was administered to the sample of Ou-students. The raw scores for the test items were recoded in order to gather a maximum of information in relation to mastery or non-mastery of the domain specific knowledge. After recoding[1], a general economics-score for the entire test was calculated.

In a next step, all items were classified along the dimensions discussed in part 2 of this text. The 154 items were analyzed - separately - by three researchers. In reviewing the items, the researchers attempted to classify each item on each one of the 10 dimensions. An inter-rater reliability was obtained $> .8^{**}$. If there was discussion in relation to the categorization of a specific item along a dimension, discussion resulted in a consensus on the final evaluation of the item. Grouping the items along the knowledge profile dimensions helped to calculate specific subscores. To ease comparison of mean total subscores, the individual subscores have been calculated as %-scores.

4 Discussion of the research results

4.1 General Results

Table 2 on the next page gives an overview of the mean scores and subscores for the entire test and the different regrouping of items along the 10 dimensions[3]. The name of each dimension is given in the first column. Next the names of the different parameters along the dimensions are recited, with - in the third column - the number of items that have been identified as exponents of this parameter. Another striking fact is the large difference in the number of items that help to calculate the parameter-subscores. Some N_{item}-values are even problematic. The "Reason" parameter along the "Node Relation" dimension is e.g. represented by only two items, making this parameter less useful and weakening the validity of this dimension. This has to be taken into account when interpreting the analysis results.

The mean % score of the total research sample for each specific parameter is reported in the fourth column. The mean % scores for the different parameters in relation to each dimension show sometimes striking differences. The subtopic dimension presents for instance mean % scores varying from 18.3 % to 44.37 %. This suggests - a first level - that some dimensions/parameters can help to indicate mastery or non-mastery of components of the prior knowledge state. Next to the differences in mean scores, especially the large σ-values draw our attention. These large values are the result of the fact that the test measures " the prior knowledge state" of students with a wide variety of prior experiences in relation to the topics assessed by the test. In the sixth and seventh column, the mean % scores of our specific research populations are reported. First the scores of the 25% group are reported, next these of the 50 % group. The same striking differences in mean % scores and σ-values can be observed.

---

[1] The normal scoring procedure for this test implies that students obtain +1 when their answer is correct; obtain 0 when they answer with ? and obtain -1 when their answer is wrong. In the recoding process, scoring for wrong answers was changed into a zero-score.

[2] $^{*} = p \leq 0.5$ $^{**} = p \leq .01$

[3] The concept "significant" in this report refers to "statistically significant" results.

Table 2 :
Overview of general results

DIMENSION	PARAMETERS	N_{item}	overall m_{item}	overall σ	$m_{20\%}$LE	$m_{20\%}$HE	$m_{80\%}$LE	$m_{80\%}$HE
Economics subdomains	Reporting	18	24.99	14.14	21.30	28.09	16.65	33.02
	Financing	18	26.07	15.30	21.30	29.48	15.88	35.88
	Organisation	18	34.02	18.26	28.24	38.35	21.70	45.88
	Marketing	18	35.55	16.51	31.98	38.39	25.10	45.63
	Macro-economics	25	25.99	14.40	21.03	27.97	16.74	34.90
	Micro-economics	25	24.67	14.55	19.33	24.31	16.21	32.82
	Public finances	11	33.27	18.35	28.35	36.11	22.95	43.22
	Intern. economics affairs	11	27.58	17.84	22.98	28.66	18.03	36.79
	Behavioural & social sciences	10	17.28	17.48	10.90	19.10	7.38	26.81
Curriculum level	First year level	102	30.79	12.35	26.84	33.56	21.49	39.76
	Second year level	52	21.91	15.76	15.30	23.16	11.24	32.18
Curriculum accent	General economics & B.A.	15	28.18	12.56	23.07	30.53	18.08	37.90
	Quantitative economics	139	24.22	13.32	21.76	25.65	17.52	30.68
Node relation parameters	Reason	2	28.09	34.78	23.07	35.42	15.17	40.53
	Initiate	8	19.84	17.84	17.71	21.35	10.09	29.24
	Consequence	58	29.14	13.02	14.41	31.12	19.47	38.46
	Manner	5	39.56	23.82	24.44	43.75	28.07	50.63
	Property	81	26.87	12.33	35.97	29.17	17.23	36.17
Behavioural level	Know	24	29.89	15.31	22.04	33.02	19.34	40.06
	Understand	99	28.97	13.19	24.77	31.51	18.42	39.13
	Apply	31	22.40	11.30	23.70	23.10	15.75	28.81

Content level	Facts	6	21.57	19.07	19.13	24.54	12.93	29.90
	Concepts	21	35.23	16.61	16.32	39.02	24.06	46.01
	Relations	32	31.13	14.44	30.09	33.70	21.02	40.86
	Structures	56	26.60	13.28	27.30	28.37	16.45	36.39
	Methods	39	23.71	12.21	20.92	25.48	15.38	31.73
Epistemological	Knowledge identification	15	28.97	16.02	19.44	32.59	18.90	38.67
	Knowledge conceptualisation	10	36.50	19.86	24.07	40.76	24.59	47.97
	Epistemological analysis	84	28.17	13.19	30.49	30.27	17.92	38.06
	Logical analysis	15	29.99	17.31	23.13	34.07	17.95	41.59
	Implementational analysis	30	22.13	11.24	23.47	22.57	15.75	28.27
Amount of propositions	< 5	82	27.22	12.44	19.07	29.50	17.65	36.44
	> 5 < 10	44	13.62	5.94	22.62	14.74	9.35	17.74
	> 9	28	6.85	4.10	11.53	7.35	3.94	9.66
Information level	Items with stem	105	29.86	13.09	5.26	32.22	19.52	39.82
	Items without stem	49	39.34	19.50	24.56	42.76	25.05	53.10
Representation level	Textual-graphical	99	36.98	20.61	33.33	39.20	26.67	46.92
	Textual	9	28.73	13.06	23.60	31.54	18.29	38.78
	Schematic	14	28.55	15.99	23.81	31.89	18.45	38.28
	Symbolic	32	22.34	12.18	18.21	22.53	15.02	29.38
ECONOMICS TESTSCORE		154	42.80	18.72	35.33	46.28	27.76	57.29

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4.2 Profiles of students with low (LE) and high (HE) expertise : a first analysis

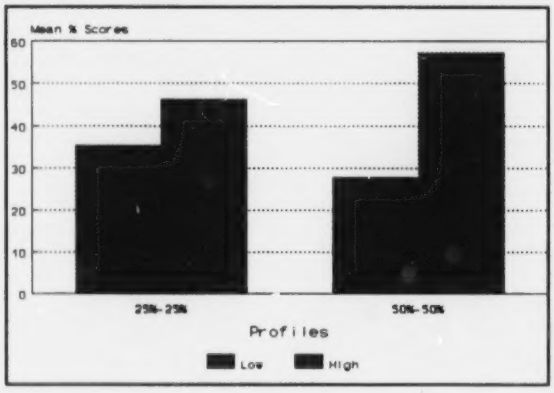

Figure 2 : Profiles subpopulations

As expected there are striking differences between the means of both subpopulations. T-tests or analysis of variance[1] confirms these significant differences ($F_{25\%} = 796.4$ $p_{F25\%} = .000$; $F_{50\%} = 970.7$ $p_{F50\%} = .000$)[2].

When discussing the profiles in relation to the different dimensions, two approaches will be adopted. First, the profiles of both subpopulations (50%-50% and 25%-25%) will be compared. Next we will enter into the profiles and analyze particularities of the overall profile structure (independent of the subpopulations) or striking differences in-between the parameters. The latter analysis will be complemented in the next part of this text when executing a flatness test based on a multivariate analysis of variance (profile analysis).

4.2.1 Economics subdomains dimension

The data in fig. 3 and 4 reveal clear differences in the mean % scores of students with a low (LE) and a high prior knowledge state (HE) for the different economics-subdomains. As expected, the mean % scores of HE are always higher for all subdomains. If we neglect the interrelations between the different economics-subdomains, and test the significance of the differences between the mean-scores[3] we find that these differences are always significant ($p_F < .000$)[4].

---

[1] For most parameters, the variances of the 25%-25% group are homogeneous and an analysis of variance can be executed. But for the 50%-50% group, the variances are not homogeneous. As a result only t-tests will be calculated to compare the mean % scores of the subpopulations in relation to this subvision in the population. In this part of the text we will. At the end of this part (4.2), we will summarize the analysis findings. The reader will find whether t-tests or variance analysis have been applied.

[2] The concept "significant" in the further part of this text refers to "statistical significance".

[3] In part 5.3 of this text, we will take the intercorrelation between the subdomains into account when executing a parallelism test, based on a multivariate analysis of variance (profile analysis).

[4] For an overview of the F- and p_F-values, we refer to table 3.

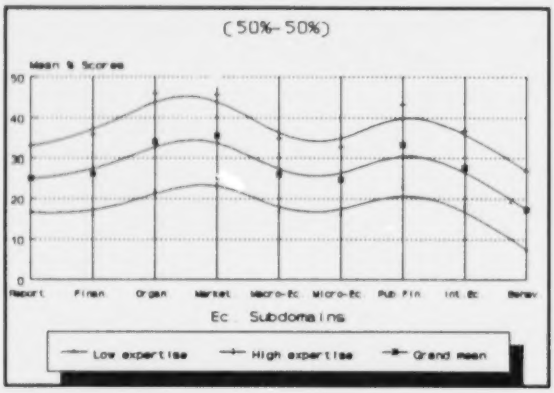

Figure 3 : Economics Subdomains knowledge profiles (50%-50%)

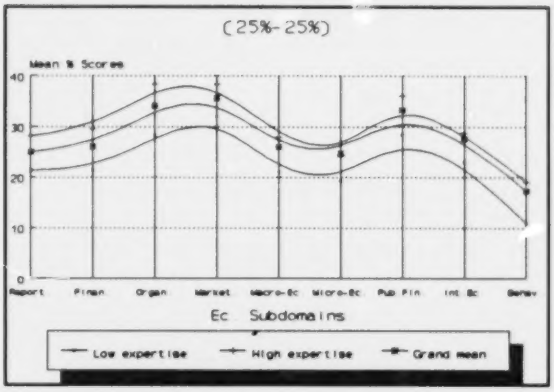

Figure 4 : Economics Subdomains knowledge profiles (25%-25%)

There is a remarkable difference in the profile-comparison of the 50%-50% and 25%-25% groups. In the latter, the mean % score of the HE-group for the subdomain micro-economics does not differ to a large extent from the grand mean. Also for the subsequent subdomains (Public finances, International economic affairs and Behaviourial and social sciences) this difference is not that large. This might indicate that for these subdomains, a ceiling effect is noticed.
The difference between the mean % scores of the LE group is analogous in relation to all subdomains.

4.2.2 Curriculum accent dimension

The difference in mean % scores of HE and LE students is consistently significant for both curriculum accent parameters. When comparing the profiles, it is noticeable that the mastery of general economics of LE students is very much lower than the grand mean.

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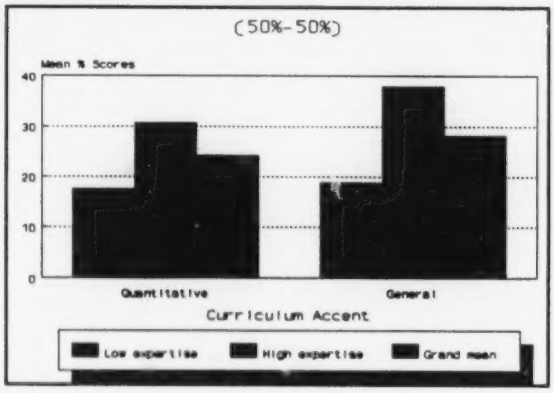

Figure 5 : Curriculum accent knowledge profile (50%-50%)

The curriculum accent profiles show that "general economics" mastery is higher than "quantitative economics" mastery for all subpopulations. This can indicate that the prior knowledge state is of more importance when solving quantitative economics problems. But, this can also be explained by linking these results to earlier research findings. When analyzing e.g. the "components" of the prior knowledge state in the field of economics, it was found that a mathematics related prior knowledge state helped to explain to a significant and relevant extent the variance in economics prior knowledge state test scores (Dochy, Valcke & Wagemans, 1991 & Wagemans, Valcke & Dochy, 1991).

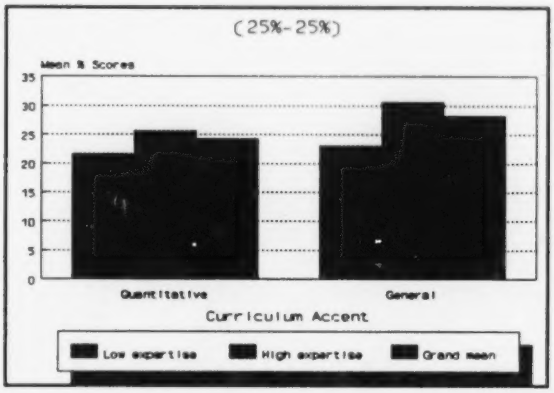

Figure 6 : Curriculum accent knowledge profile (25%-25%)

4.2.3 Curriculum level dimension

Mastery of both curriculum levels is always higher for HE students than for LE students. These differences are significant.

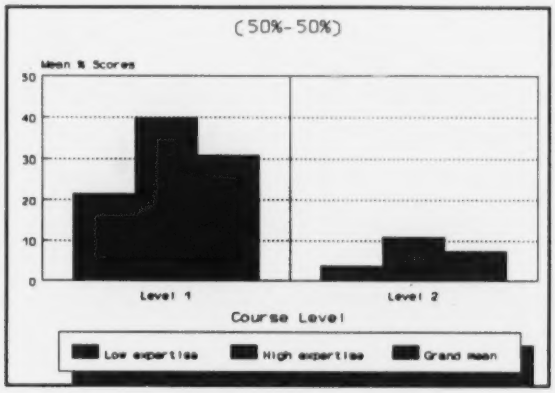

Figure 7 : Curriculum knowledge profile (50%-50%)

As expected, the mean % score for the level-2 parameter is lower for both sub-populations. It is normal that prior knowledge of these advanced level questions is restricted. An additional explanation questions the quality of the level-2 items. It is possible that these are of a much higher order.

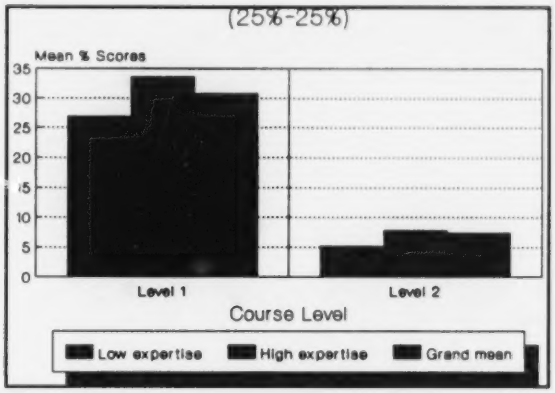

Figure 8 : Curriculum knowledge profile (25%-25%)

4.2.4 Node relation dimension

There is a consistent significant difference in the mastery of all node relation parameters between LE and HE students. Although significant, these differences are less large in the 25%-25% population. This is especially true for the parameters initiate, consequence, manner and property.

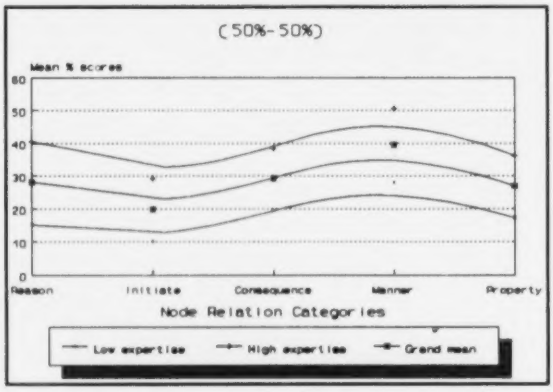

Figure 9 : Node relation knowledge profile (50%-50%)

In both figures, it is remarkable that the mean % scores for the different parameters do differ to a large extent. Items, classified as "reason" or "manner" are more easily solved than the other node relation parameters. The flatness test will indicate whether these in-profile differences are significant.

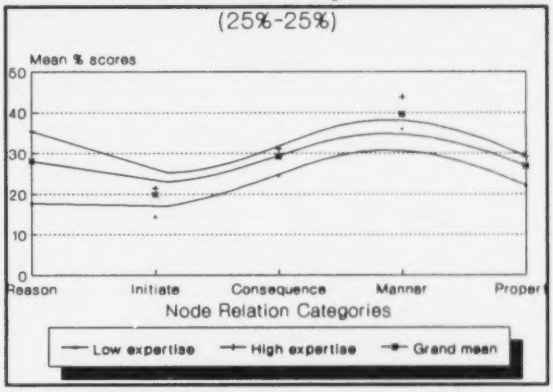

Figure 10 : Node relation knowledge profile (25%-25%)

4.2.5 Behaviourial dimension

The differences between the mastery of LE and HE students are significant at all levels.

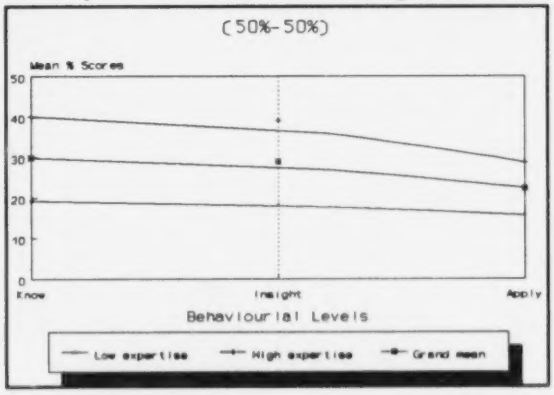

Figure 11 : Behaviourial knowledge profile (50%-50%)

At the theoretical level, it was indicated that this dimension is hierarchical. This might imply that items, classified according to the "apply" parameter are more difficult than e.g. items classified as "knowing". This is confirmed, when looking at the two figures. Mastery of higher level items is always lower than lower level items. We can also notice a ceiling effect in relation to difficult items : the mean % scores of HE student is not this different from the grand mean in the 25%-25% group.

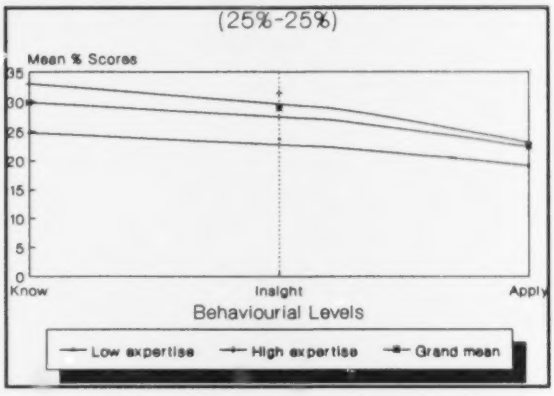

Figure 12 : Behaviourial knowledge profile (25%-25%)

4.2.6 Content dimension

The differences between the mastery of LE and HE students are significant in connection to all parameters.

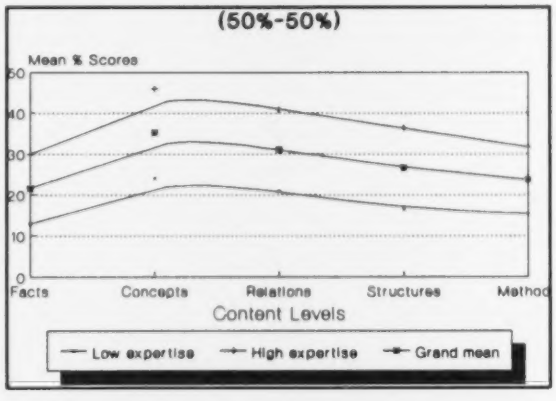

Figure 13 : Content knowledge profile (50%-50%)

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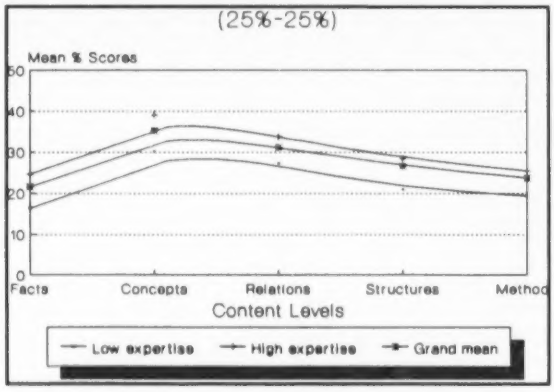

Figure 14 : Content knowledge profile (25%-25%)

Parameters, along the content dimension are considered as being hierarchical. Both pictures show some remarkable particularities in this perspective : the mastery of items linked to the "fact" parameter is consistently lower than the mastery of items linked to the "concepts, relations, structures and methods" parameters. We can explain this difference in mastery by referring to the difficulties in retaining and remembering isolated factual knowledge. Whereas, concepts are more easily recalled since at this level facts are embedded in a structure, scheme. But, since these structures or schemes become more complex when they are integrated into relations or structures, mastery of them decreases. Both figures confirm this tendency.
The mastery of items, classified according to the "methods" parameter, follows the overall trend described above.

4.2.7 Epistemological dimension

The knowledge profile of HE students is consistently and significantly higher than the profile of LE students.

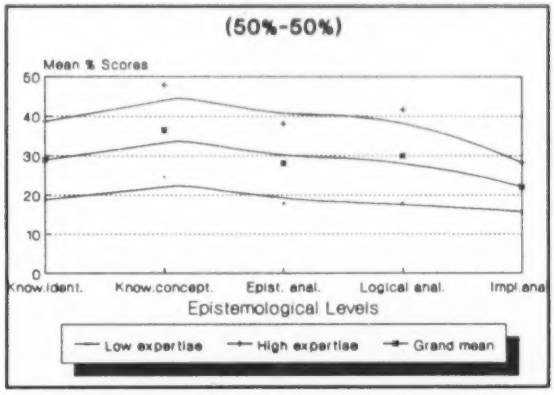

Figure 15 : Epistemological knowledge profile (50%-50%)

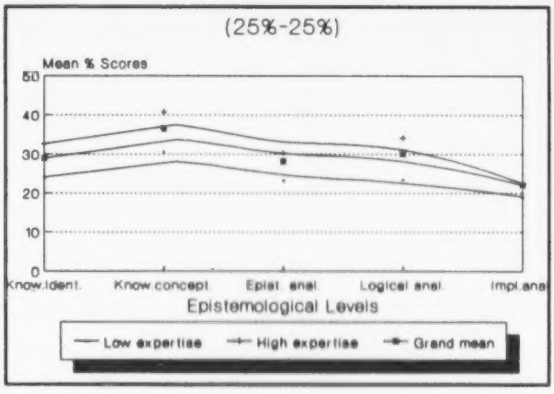

Figure 16 : Epistemological knowledge profile (25%-25%)

This dimension is a combination of the behaviourial and content hierarchical dimension. It is expected that analogous profiles will be found. Fig. 15 and 16 confirm our expectations. We can even state that the pattern in the particular expected profiles is reinforced. When looking at figure 16, we perceive that the mean % score of the HE students does hardly differ from the grand mean when looking at the parameters "Logical analysis and Implementional analysis". This can be explained as follows : the students in our research sample have - yet - not been in the position to act as economists, thus dealing with real-life problems which have to be solved by applying higher order economics knowledge. Since experience is needed to consolidate the mastery of this type of economics knowledge, we cannot expect high prior knowledge state scores.

4.2.8 Number of propositions dimension

Items with a high number of propositions are more complex than items with a low number of propositions. It is expected that HE students perform better at all proposition-levels than LE students. This is confirmed by the profiles in figures 17 and 18. The differences in performance are significant. If we look at the 25%-25% group, we see that the mean % score of the HE group does hardly differ from the grand mean.

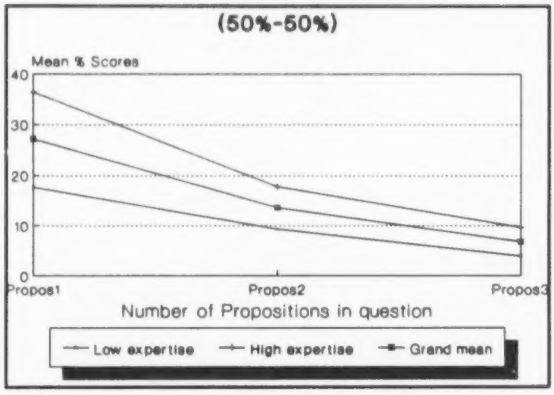

Figure 17 : Number of propositions knowledge profile (50%-50%)

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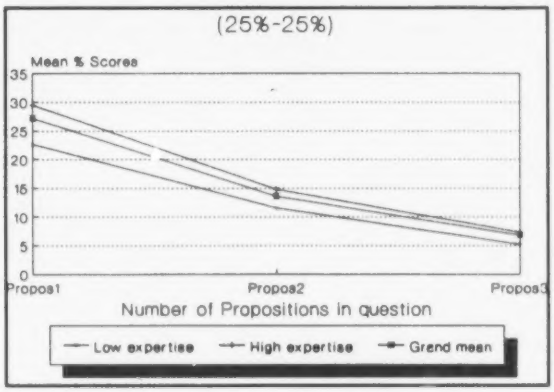

Figure 18 : Number of propositions knowledge profile (25%-25%)

Figure 17 and 18 also illustrate that the mastery of items ordered along the subsequent parameters gradually declines.

4.2.9 Information level dimension

Consistent and significant differences are found between LE and HE students.

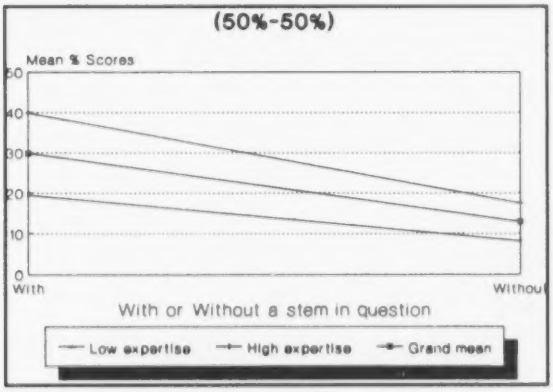

Figure 19 : Information level profile (50%-50%)

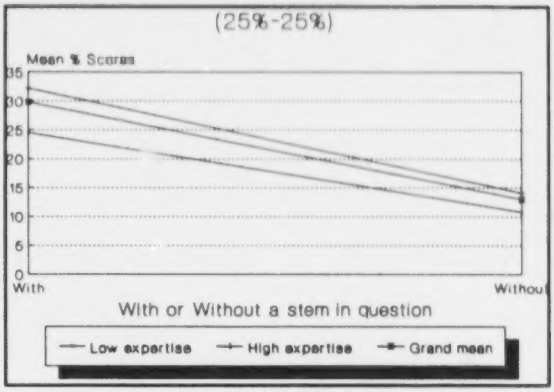

Figure 20 : Information level profile (25%-25%)

Referring to the theoretical discussion in relation to this dimension, we expect that items without a stem are more difficult than items with a stem. Figure 19 and 20 confirm our expectations. The pattern found, is also consistent with the findings in figure 17 and 18 in connection to the number of propositions dimension.

4.2.10 Representation level dimension

Consistent and significant differences are found between LE and HE students in relation to all parameters.

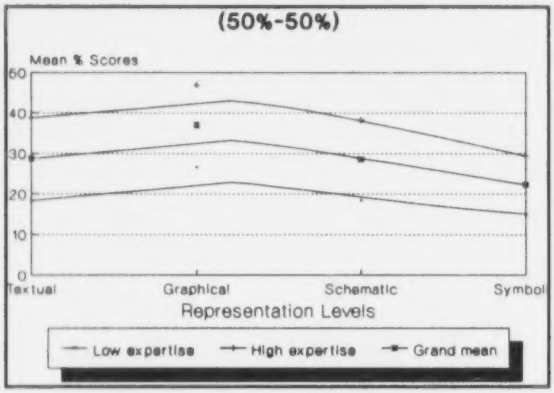

Figure 21 : Representation level knowledge profile (50%-50%)

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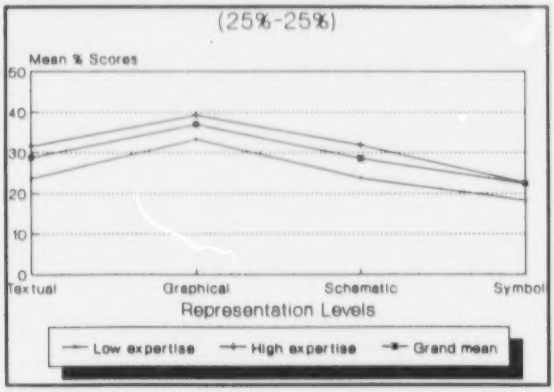

Figure 22 : Representation level knowledge profile (25%-25%)

The profiles suggest that all students are more able to solve questions based on graphical information. Addition of schematic and symbolic information to text-based items, seems not to enhance performance of students. The profiles even suggest that such items are even more difficult than purely text-based items. In addition, we perceive in figure 22 that the mean % score of the HE students (22.6%) for items classified as "textual-symbolic" is hardly different from the grand mean (20.5%).

4.2.11 Intermediate conclusions

All dimensions help to differentiate between LE and HE students. All differences between both student populations are significant, whether we consider the 25%-25% or the 50%-50% group. The reader might conclude that the dimensions have not been helpful to detect very specific contrasts between LE and HE students. But, the specification of the 25%-25% group has proven to be useful since more distinctive differences between low and high performers could be detected than comparing the 50%-50% group. The fact we tried to avoid deviation of the distribution of the mean % scores by excluding extreme scoring students from the research sample, has been successful to a certain extent.

Expectations about the knowledge profiles - based on our theoretical considerations - have been largely confirmed (e.g. hierarchical nature, subsequent difficulty levels, etc.).

Table 3 :
Comparison of mean % scores of LE and HE students in the 25%-25% group

Dimension/parameter	LE	HE	$t_{t\text{-test}}$	p_T
ES Report	21.3	28.0		
ES Finance	21.3	29.5		
ES Organ	28.2	38.3		
ES Market	31.9	38.4		
ES Macro	21.0	28.0		
ES Micro	19.3	24.3		
ES Public	28.3	36.1		
ES Internat	23.0	28.7		
ES Behav	10.9	19.0	-5.07	.000
CD Level1	26.8	33.6	-10.53	.000
CD Level2	15.3	23.1		
CA Quant	21.7	25.6		
CA General	23.0	30.5		
NR Reason	17.7	35.4	-4.79	.000
NR Initiate	14.4	21.3		
NR Consequence	24.4	31.1		
NR Manner	35.9	43.7		
NR Property	22.0	29.2		
B Know	24.7	33.0		
B Insight	23.7	31.5		
B Apply	19.1	23.0		
C Factual	16.3	24.5		
C Concept	30.0	39.0		
C Relation	27.3	33.7		
C Structure	20.9	28.4		
C Skills	19.4	25.5		
E Kident	24.0	32.6		
E Kconcept	30.5	40.8		
E Episte	23.1	30.3		
E Logical	23.5	34.0		
E Implem	19.0	22.6		
NP Propos1	22.6	29.5		
NP Propos2	11.5	14.7		
NP Propos3	5.2	7.3		
IL With stem	24.6	32.2		
IL Without stem	32.7	42.8		
RL Text	23.6	31.5		
RL Concret	33.3	39.2		
RL Scheme	23.8	31.9		
RL Symbolic	18.2	22.5		
General economics score	35.3	46.3		

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Table 4 :
Comparison of mean % scores of LE and HE students in the 50%-50% group

Dimension/parameter	LE	HE	t_{calc}	p_T
ES Report	16.6	33.0		
ES Finance	15.9	35.9	-21.04	.000
ES Organ	21.7	45.9		
ES Market	25.1	45.6		
ES Macro	16.7	34.9	-19.81	.000
ES Micro	16.2	32.8	-17.03	.000
ES Public	22.9	43.2		
ES Internat	18.0	36.8	-15.07	.000
ES Behav	7.4	26.8	-16.38	.000
CD Level1	21.5	39.7		
CD Level2	11.2	32.2	-21.08	.000
CA Quant	17.5	30.7	-13.37	.000
CA General	18.1	37.9	-31.38	.000
NR Reason	15.2	40.5	-9.57	.000
NR Initiate	10.1	29.2	-15.57	.000
NR Consequence	19.5	38.5	-26.06	.000
NR Manner	28.1	50.6		
NR Property	17.2	36.2	-29.03	.000
B Know	19.3	40.1	-22.43	.000
B Insight	18.4	39.1	-31.01	.000
B Apply	15.7	28.8	-17.32	.000
C Factual	12.9	29.9	-30.84	.000
C Concept	24.0	46.0		
C Relation	21.0	40.9		
C Structure	16.4	36.4	-27.84	.000
C Skills	15.4	31.7	-22.07	.000
E Kident	18.9	38.7	-19.12	.000
E Kconcept	24.6	47.9		
E Episte	17.9	38.0	-28.92	.000
E Logical	17.9	41.6	-22.84	.000
E Implem	15.7	28.3	-16.42	.000
NP Propos1	17.6	36.4	-28.15	.000
NP Propos2	9.3	17.7	-24.32	.000
NP Propos3	3.9	9.7	-23.85	.000
IL With stem	19.5	39.9	-30.01	.000
IL Without stem	25.0	53.1	-25.29	.000
RL Text	18.3	38.8	-30.84	.000
RL Concret	26.7	46.9		
RL Scheme	18.4	38.3	-19.27	.000
RL Symbolic	15.0	29.4	-17.87	.000
General economics score	**27.8**	**57.3**	**-31.34**	**.000**

4.3 Profile analysis

A univariate analysis of variance (as used in part 4.2 of this text) does not take into account the intercorrelations between the different parameters along the profile dimensions. These intercorrrelations are important (although not making the specific variables redundant) and can be explained at the theoretical level as illuminated elsewhere (cf. Dochy & Valcke, 1991a). A multivariate analysis of variance is needed to refine our analysis and to look for more conclusive information about the differences in the prior knowledge state between LE and HE students. A multivariate analysis can take these intercorrelations into account. Profile analysis is an extension of multivariate analysis and is especially appropriate and helpful to evaluate the parameter structure in relation to each profile dimension when comparing subpopulations. Several tests are available in profile analysis. Of principal interest - for our purposes - is the **"parallelism"** test which help to answer the question whether the profiles of two subpopulations are parallel or not. If certain dimensions are helpful to detect non-parallel profiles, it might be interesting to know what parameter along the dimension does contribute most to these significant differences. Therefore, for non-parallel profiles, the analysis will be extended with a **discriminant analysis** (also called, the "level" test). At the theoretical level - as suggested in part 4.2 of this text - also the **"flatness"** test might be relevant, since this test controls the similarity of responses for the different parameters along a dimension, independent of groups or subgroups. An answer to this question helps to support the validity of the different dimensions since the results indicate whether or not the dimensions/parameters are helpful to specify differences in the mastery of different components of the prior knowledge state.
A profile analysis will be performed on the complex of parameters in relation to each dimension. The grouping variable is defined by LE and HE. SPSS-PC$^+$ MANOVA was used for our profile analysis.

4.3.1 Control of underlying assumptions

Profile analysis implies that specific assumptions about the quality of the research data are met (no missing data, comparable sample sizes, (multivariate) normal distributions, no outliers, homogeneity of variance-covariance, multicollinearity).

- Data screening revealed no missing data.
- Sample sizes are nearly equal for all subpopulations ($N_{LE\ 25\%}$ = 144 ; $N_{HE\ 25\%}$ = 153; $N_{LE\ 50\%}$ = 290;
  $N_{HE\ 50\%}$ = 301) so no special difficulties are expected. Moreover, only one independent variable is used.
- The evaluation of the homogeneity of variance-covariance matrices is based on the Cochrans C and the Bartlett-Box F test.
- To evaluate assumptions about multivariate normality, boxplots of the mean submeasures for each dimension have been screened.
- Multicollinearity is tested with the Bartlett test of sphericity.

The research data for the 25%-25% and 50%-50% group have been screened separately.

In evaluating **multivariate normality** of the distribution of the mean %-scores, it is to be mentioned that the σ-values are very high, indicating a wide dispersion of the scores (cf. table 2). This is to be expected, since the test measures " the prior knowledge state". Figure 13 presents e.g. a box-plot of the scores of ES and LS for the subtopic "marketing" on the "Economics subdomain" dimension. The wide dispersion of the scores is obvious. The * identifies the median and the box contains the middle 50% of the values.
The lines emanating from the box extend to the smallest and largest observations in the subgroups that are less than one interquartile range from the end of the box. Points outside this range are marked with O (outliers) or even E (Extremes) if more than 1.5 interquartile distances away from the box.

Analysis of the box-plots for each variable in relation to each profile dimension reveals that there are outliers and extremes. This is especially true for the 50%-50% groups. As argumented earlier in this text, a new subdivision of the large student sample has been effected in order to diminish the impact of these extreme scoring students in the research sample. The box-plots of the 25%-25% groups depict as a consequence less outlying and extreme values.

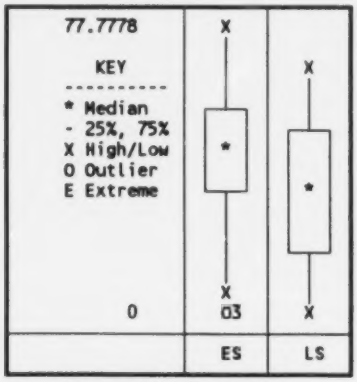

Figure 23 : Box-Plots For Variable .. MARKET

Table 5 and 6 on the next page summarize the data in relation to the evaluation of the homogeneity of variance-covariance matrices and the multicollinearity test.

As can be concluded from table 6, representing the data for the 50%-50% groups, the Cochrans C and Bartlett-Box F values are significant in relation to all dimensions and nearly all parameters. This makes a straightforward interpretation of the multivariate analysis of variance results hardly possible. As a consequence we prefer not to involve the 50%-50% groups subdivision in the further analyses.
When analyzing the data in relation to the 25%-25% groups, only minor violations against the **homogeneity of variance-covariance** are observed (subdomains, level and node relation dimension). But since the sample sizes are sufficiently large and comparable, no problems are expected.

The Bartlett test of sphericity is significant in all cases, even within the 25%-25% groups, which means that the variables are highly intercorrelated. Although the p-values are very small, the SPSS-MANOVA-PC[+] procedure protects against instability caused by **multicollinearity** by excluding variables from the analysis with too low tolerance levels[1]. The fact, the MANOVA-procedure was never halted during execution indicates that multicollinearity did not cause problems.

In general we can summarize that assumptions are met in order to execute a profile analysis on the research data available if we restrict our analysis to the 25%-25% groups.

[1] Tolerance level = 1 - SMC (squared multiple correlation of each variable).

Table 5 :
Analysis data in relation to multicollinearity
and homogeneity of variance-covariance matrices (25%-25%)

	Homogeneity of Variance		Multicollinearity Bartlett test of sphericity
	Cochrans C	Bartlett-Box F	
Report	.52264 (p=.582)	.30172 (p=.583)	
Finance	.50310 (p=.940)	.00564 (p=.940)	
Organ	.53886 (p=.344)	.88855 (p=.346)	
Market	.53533 (p=.390)	.73621 (p=.391)	
Macro	.57166 (p=.080)	3.03883 (p=.081)	275.58412 (p=.000)
Micro	.57362 (p=.072)	3.20920 (p=.073)	
Public	.51133 (p=.783)	.07553 (p=.783)	
Internat	.52511 (p=.542)	.37049 (p=.543)	
Behav	.60899 (p=.007)	7.11806 (p=.008)	
Level1	.63825 (p=.001)	11.61489(p=.001)	296.25458 (p=.000)
Level2	.59317 (p=.022)	5.17010(p=.023)	
Quant	.56609 (p=.107)	2.58189 (p=.108)	22.47357 (p=.000)
General	.56172 (p=.432)	2.24948 (p=.134)	
Reason	.64194 (p=.000)	12.26879 (p=.000)	
Initiate	.57858 (p=.055)	3.66137 (p=.056)	
Conseq	.58794 (p=.031)	4.59869 (p=.032)	60.03420 (p=.000)
Manner	.53088 (p=.453)	.56060 (p=.454)	
Property	.50125 (p=.976)	.00092 (p=.976)	
Know	.53312 (p=.421)	.64479 (p=.422)	
Insight	.55385 (p=.190)	1.70983 (p=.191)	55.60628 (p=.000)
Apply	.59257 (p=.023)	5.10368 (p=.024)	
Factual	.55243 (p=.202)	1.62028 (p=.203)	
Concept	.54704 (p=.252)	1.30341 (p=.254)	
Relat	.51130 (p=.784)	.07511 (p=.784)	96.36344 (p=.000)
Struct	.57648 (p=.062)	3.46616 (p=.063)	
Methods	.56499 (p=.113)	2.49574 (p=.114)	
Kident	.50769 (p=.852)	.03472 (p=.852)	
Kconcept	.54947 (p=.228)	1.44159 (p=.230)	
Episto	.59939 (p=.015)	5.59752 (p=.015)	88.89663 (p=.000)
Logical	.57297 (p=.075)	3.15242 P=.076)	
Implem	.59131 (p=.025)	4.96308 (p=.026)	
Propos1	.59374 (p=.022)	5.23483 (p=.022)	
Propos2	.58138 (p=.047)	3.93047 (p=.048)	96.35997 (p=.000)
Propos3	.57109 (p=.083)	2.99083 (p=.084)	
Withs	.60097 (p=.013)	6.08923 (p=.014)	50.61913 (p=.000)
Withouts	.57527 (p=.066)	3.35610 (p=.067)	
Text	.52252 (p=.584)	.29801 (p=.585)	
Concret	.56315 (p=.124)	2.35568 (p=.125)	76.13433 (p=.000)
Scheme	.56284 (p=.125)	2.33262 (p=.127)	
Symbol	.54343 (p=.291)	1.11025 (p=.292)	

Table 6 :
Analysis data in relation to multicollinearity
and homogeneity of variance-covariance matrices (50%-50%)

	Homogeneity of Variance		Multicollinearity Bartlett test of sphericity
	Cochrans C	Bartlett-Box F	
Report	.55951 (p=.017)	5.72573 (p=.017)	
Finance	.58297 (p=.004)	8.19001 (p=.004)	
Organ	.54908 (p=.091)	2.84202(p=.092)	
Market	.50558 (p=.848)	.03666 (p=.848)	
Macro	.61940 (p=.000)	17.20529 (p=.000)	960.22167 (p=.000)
Micro	.70183 (p=.000)	52.01233 (p=.000)	
Public	.53973 (p=.172)	1.86011 (p=.173)	
Internat	.61233 (p=.000)	15.17855 (p=.000)	
Behav	.73090 (p=.000)	70.08597 (p=.000)	
Level1	.56066(p=.037)	4.35169(p=.037)	29.91204 (p=.000)
Level2	.73824 (p=.000)	75.23063(p=.000)	
Quant	.63419 (p=.000)	21.89541 (p=.000)	94.61048 (p=.000)
General	.66160 (p=.000)	32.29598(p=.134)	
Reason	.66324 (p=.000)	32.99057 (p=.000)	
Initiate	.69352 (p=.000)	47.46595 (p=.000)	
Conseq	.65119 (p=.000)	28.07583 (p=.000)	504.97102 (p=.000)
Manner	.56572 (p=.023)	5.11414 (p=.024)	
Property	.65112 (p=.000)	28.04990(p=.000)	
Know	.60879 (p=.000)	14.21446 (p=.000)	
Insight	.64560 (p=.000)	25.94753 (p=.000)	384.32928 (p=.000)
Apply	.69796 (p=.000)	49.86202 (p=.000)	
Factual	.67159 (p=.000)	36.66917 (p=.000)	
Concept	.52773 (p=.341)	.90505 (p=.342)	
Relat	.56723 (p=.020)	5.35307 (p=.021)	646.84117 (p=.000)
Struct	.69566 (p=.000)	48.61243 (p=.000)	
Methods	.68988 (p=.000)	45.55333 (p=.000)	
Kident	.57685 (p=.008)	7.01218 (p=.008)	
Kconcept	.53637 (p=.211)	1.55762 (p=.212)	
Episto	.66301 (p=.000)	32.89280 (p=.000)	525.73181 (p=.000)
Logical	.64039 (p=.000)	24.05157(p=.000)	
Implem	.70179 (p=.000)	51.98872 (p=.000)	
Propos1	.62510 (p=.000)	18.94130 (p=.000)	
Propos2	.58310 (p=.004)	8.21516 (p=.004)	447.41569 (p=.000)
Propos3	.71850 (p=.000)	61.94216 (p=.000)	
Withs	.67048 (p=.000)	36.16804 (p=.000)	262.10691 (p=.000)
Withouts	.61901 (p=.000)	17.09039 (p=.000)	
Text	.62132 (p=.000)	17.78058 (p=.000)	
Concret	.56635 (p=.022)	5.21240 (p=.023)	365.72403 (p=.000)
Scheme	.59133 (p=.002)	9.95045 (p=.002)	
Symbol	.71075 (p=.000)	57.18240 (p=.000)	

4.3.2 Profile Analysis Results : Parallelism Test

Table 7 presents an overview of the profile analysis results in connection to the parallelism test. This helps us to answer the question whether the two different student groups (LE and HE) have parallel or non-parallel profiles. This is commonly known as the test of parallelism and is the primary question addressed by profile analysis[1]. In relation to each profile dimension, Wilk's Lambda (λ) was calculated and p-levels determined. In the results table, Wilk's λ is not reported in relation to three dimensions (marked with *). This is because these dimensions only contain two variables; in these cases a test of significance for Hoteling's T2, using the unique sums of squares, was calculated checking the interaction of the independent variable (LE and HE) and the two dependent variables on the specific dimensions.

Table 7 :
Results of the parallelism test in profile analysis

DIMENSION	Wilks λ or F	p_λ or p_F
Economics subdomains	.96459	.232
Curriculum level*	20.94	.000
Curriculum accent*	536.17	.003
Node relation	.96662	.041
Behaviourial level	.93784	.659
Content level	.97667	.140
Epistemological	.24876	.000
Number of propositions	.79462	.000
Information level*	53.55*	.000
Representation level	.95832	.006

The data in table 7 help to detect specific significant differences in knowledge profiles of LE and HE students. Significant differences are reported in relation to the following dimensions : course level, curriculum level, behaviourial level, number of propositions, information level and representation level. Therefore, the hypotheses stated in part 3.1 of this text can be confirmed to a very large extent.
Since the results indicate non-parallel profiles, a discriminant analysis and the calculation of structure coefficients are relevant.

4.3.3 Discriminant Analysis : Structure Coefficients

As said in the introduction to profile analysis, a further analysis of non-parallel profiles might be interesting in order to know what specific parameter(s) along the dimension does or do contribute most to these differences in profiles. Table 8 presents the results of a discriminant analysis. In the second and third column a new value for Wilk's λ is reported and its significance level[2]. Moreover, Wilk's λ can - in this context - be interpreted as a measure indicating the proportion of variability not explained by the group differences. In the fourth column, we derive from λ $((1 - \lambda) * 100)$ the proportion of variability that is explained by the group differences based on the independent variable (LE and HE).

[1] When using profile analysis as a substitute for univariate repeated measures ANOVA, the parallelism test is the test of interaction.

[2] Of course this further analysis is limited to the dimensions resulting in non-parallel profiles.

Table 8 :
Results of the discriminant analysis

DIMENSION	Wilks λ	p_λ	% explained
Curriculum level*	.26612	.000	73 %
Curriculum accent*	.26933	.000	73 %
Epistemological	.24876	.000	75 %
Number of propositions	.26331	.000	73 %
Information level*	.26167	.000	73 %
Representation level	.27316	.000	72 %

Since this extension of our profile analysis indicates significant λ, the analysis can be continued by calculating structure coefficients[1] to determine the discriminatory power of the separate values for each dimension parameter. The results of this further analysis are reported in table 9. Only the most relevant structure coefficients in relation to each dimension are reported.

Table 9 :
Overview of most relevant structure coefficients

Dimension	Parameter	Structure coeff.
Curriculum level	Level1	.371
Curriculum accent	General	.917
Epistemological	Epist. an.	-.524
Number of propositions	< 5 prop.	-.472
Information level	With stem	.701
Representation level	Textual	-.679

The results in table 9 could be predicted since the structure coefficients reflect the large F-values we already obtained when reporting the results of the univariate analysis of variance in mean % scores in part x of this text.

4.3.4 Profile Analysis Results : Flatness Test

Is the mastery of the prior knowledge state as defined by the parameters along a dimension different, independent of the groups (a within-subjects main effect) ? In other words, do students master the prior knowledge state in a similar way as defined by the different parameters along a dimension ? This question is especially relevant for parallel profiles, since in non-parallel profiles at least one parameter is not flat; nevertheless also the results in relation to non-parallel profiles are reported.

[1] Since the subvalues on each profile dimension are highly intercorrelated, we cannot use raw or standardized discriminant function coefficients. The highly correlated variables "share" the discriminants weights. It is safer to base our interpretation on the structure coefficients which are less likely to be influenced by these intercorrelations.

Table 10 :
Results of the flatness test in profile analysis

DIMENSION	Wilks λ or F	p_λ or p_F
Economics subdomains	.33278	.000
Curriculum level*	2415.11*	.000
Curriculum accent*	26.46*	.000
Node relation	.50081	.000
Behaviourial level	.59964	.000
Content level	.42087	.000
Epistemological	.49229	.000
Number of propositions	.05396	.000
Information level*	2760.67	.000
Representation level	.46463	.000

If the flatness test is non-significant, then the profiles are not helpful to clarify or detect differences in the mastery of different components of the prior knowledge state. The results of the flatness test are therefore also of relevance to determine the validity of the knowledge profile dimensions.
The results of the flatness test are found in table 10. For each dimension Wilk's λ has been calculated, with the exception of the three dimension where only two parameters are available along the dimension; there the F-value is reported (marked with *). All dimensions result in non-flat knowledge profiles. This implies that all dimensions are helpful to identify a specific structure in the mastery of the prior knowledge state. Following this structure, the mastery of certain components[1] of the prior knowledge state is better than for other components.

5 Conclusions

In this text, we attempted to analyze the prior knowledge state of two specific Open university subpopulations, studying a multi-functional course. Earlier research helped to confirm that the prior knowledge state differences do exist between these economics and law students. In the present study, the overall economics score was not significantly different between both student groups. But in this research, special attention was paid to a further elaboration of this general economics-score by grouping items along a variety of profile dimensions. Although a profile analysis could not help to reveal specific significant differences between the two subpopulations, the present study is of high importance since we succeeded in defining and operationalising a new more promising approach towards the analysis of the prior knowledge state. It is foreseen that in situations where there are significant differences between the prior knowledge state of specific subpopulations, the profile dimension might be helpful to detect and dissect the strengths and weaknesses of the students involved. This might be a promising starting point for differentiated diagnostic and guidance approaches.

[1] The concept "components" refers to this subpart of expertise that can be isolated in connection to a specific parameter along a knowledge profile dimension.

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